Appendix B: Level of Service Methodology

B.1 Highway Segment Existing Level of Service

B.1.1 Methodology Overview

Currently, the Highway Capacity Manual (TRB 2000) classifies two-lane highways as either Class I or Class II highways. Highway classification establishes the measures of effectiveness that are used to determine the level of service along highways such as US 40. For this analysis, the US 40 corridor was classified as a Class I highway. This classification uses both percent time spent following and average travel speed to determine the level of service; these indicators generally relate to how the traveling public measures performance along a two-lane road.

The highway segment analysis was applied to segments outside the limits of urban areas. The analysis took existing passing lanes along the US 40 corridor into account. Table B.1-1 shows the definitions used to determine the level of service along two-lane highways.

Table B.1-1. Definitions of Levels of Service on Highways

Level of Service	Percent Time Spent Following (%)	Average Travel Speed (mph)
A	< 35	> 55
B	> 35-50	> 50-55
C	> 50-65	> 45-50
D	> 65-80	> 40-45
E	> 80	< 40

Source: TRB 2000

The existing conditions analysis used the two-lane analysis module of the Highway Capacity Software (HCS). Traffic counts conducted at various locations along the US 40 corridor provided the base traffic count information. A monthly seasonal factor was calculated from a permanent count site near MP 111 to determine seasonal variations in traffic numbers. This seasonal factor was used to adjust the base traffic count information, which was used to estimate average traffic flow. Information about the percentage of trucks was determined from a classification count conducted by UDOT along US 40 in February 2007. In

general, speed limits varied from 55 mph to 65 mph within the two-lane segments. At locations where passing lanes were not provided, the percent no-passing zone was a key input to determining the existing level of service.

The segments that were used for the highway level of service analysis are different from the project segments. Urban areas were not included in the highway segment analysis because roads through such areas function differently than rural highway segments do. Gaps in the segments used for the highway level of service analysis represent urban areas that were not included in the analysis.

Table B.1-2 provides a summary of the data inputs used for the existing conditions analysis.

Table B.1-2. Information Used for the Existing Conditions Level of Service Analysis

LOS Analysis Segment	Begin MP	End MP	Section Length (miles)	Shoulder Width (ft)	Year Volume	2007 % Truck	% No Passing Zone
1	21.40	35.64	14.24	4	3,213	21	93
2	35.64	42.97	7.33	4	3,213	21	83
3	42.97	58.34	15.37	4	2,956	21	83
4	58.34	72.33	13.99	4	3,291	21	83
5	72.33	85.86	13.53	4	3,291	21	83
6	86.81	104.57	17.76	4	4,471	21	83
7	105.56	110.34	4.78	4	6,049	21	76
8	115.20	116.62	1.42	4	7,856	21	86
9	116.62	120.34	3.72	4	11,055	21	79
10	121.90	137.55	15.65	4	8,244	21	79
11	137.55	139.83	2.28	4	11,919	21	79
12	149.94	157.10	7.16	4	9,878	21	86

B.1.2 Summary of Two-Way Analysis

This section briefly summarizes the level of service of each section along the study corridor. The level of service for each segment is based on the two-way design hourly volumes and, where present, the effect that passing lanes have on a directional basis of a specific roadway segment.

In general, the existing (2007) level of service along the US 40 corridor is LOS D or better, except for one segment just outside Vernal/Naples, as shown in Table B.1-3 and Table B.1-4 below. The calculated average travel speed ranged from 36 mph to 59 mph with most segments in the low- to mid-50-mph range. The percent time spent following ranged from 24% to 73% with most segments in the 30% to 40% range.

Table B.1-3. Two-Way HCS Analysis for the AM Peak Period on US 40 by LOS Analysis Segment

LOS Analysis Segment	Begin MP	End MP	Section Length (miles)	Volume EB/WB	LOS	Average Speed (mph)	% Time Spent Following (seconds)
1	21.40	35.64	14.24	131/111	A	59.1	25.5
2	35.64	42.97	7.33	131/111	C	53.9	54.1
3	42.97	58.34	15.37	114/108	A	59.7	24.4
4	58.34	72.33	13.99	114/108	A	55.5	32.0
5	72.33	85.86	13.53	129/125	A	58.0	27.1
6	86.81	104.57	17.76	164/133	D	44.4	58.1
7	105.56	110.34	4.78	265/261	B	55.5	42.9
8	115.20	116.62	1.42	265/261	E	37.7	63.8
9	116.62	120.34	3.72	351/324	C	49.1	54.8
10	121.90	137.55	15.65	230/281	C	47.0	63.0
11	137.55	139.83	2.28	395/310	C	54.4	57.0
12	149.94	157.10	7.16	369/324	D	51.3	69.8

Table B.1-4. Two-Way HCS Analysis for the PM Peak Period on US 40 by LOS Analysis Segment

LOS Analysis Segment	Begin MP	End MP	Section Length (miles)	Volume EB/WB	LOS	Average Speed (mph)	% Time Spent Following (seconds)
1	21.40	35.64	14.24	123/129	A	57.8	26.9
2	35.64	42.97	7.33	123/129	C	53.8	55.4
3	42.97	58.34	15.37	113/112	A	59.9	24.5
4	58.34	72.33	13.99	113/112	A	55.9	30.4
5	72.33	85.86	13.53	122/130	A	58.1	26.3
6	86.81	104.57	17.76	169/190	D	44.0	56.6
7	105.56	110.34	4.78	348/327	C	54.9	50.2
8	115.20	116.62	1.42	348/327	E	36.5	69.0
9	116.62	120.34	3.72	483/446	C	47.7	63.8
10	121.90	137.55	15.65	282/344	D	47.0	66.9
11	137.55	139.83	2.28	560/448	D	52.2	68.2
12	149.94	157.10	7.16	354/448	D	51.2	73.3

Both average travel speed and percent time spent following were adversely affected in areas where no passing lanes exist and in areas that are just outside of urban areas.

B.2 Intersection Level of Service

B.2.1 Methodology Overview

The Transportation Research Board (TRB) defines the following six levels of service to measure the performance of signalized corridors:

- A: Free flow of traffic
- B: Reasonably free flow
- C: Stable flow
- D: Approaching unstable flow
- E: Unstable flow
- F: Forced or breakdown flow

Additionally, the Highway Capacity Manual defines level of service at intersections as a function of the average overall delay time for a vehicle to pass through an intersection. This quantitative measurement provides a performance indicator for the corridor. Table B.2-1 lists the definitions of level of service at intersections.

Table B.2-1. Definitions of Level of Service at Signalized Intersections

Level of Service	Intersection Delay (seconds)
A	0 to 10
B	10 to 20
C	20 to 35
D	35 to 55
E	55 to 80
F	> 80

Source: TRB 2000

The current performance of urban sections along the US 40 corridor through Vernal and Roosevelt was analyzed to develop a baseline of existing traffic conditions. Information from signalized intersections was entered into Synchro 6.0, a widely used traffic signal evaluation tool, and the results were used to develop this baseline.

Vehicle turning movements at intersections were counted manually at most signalized intersections along the study corridor. These counts were completed during the morning (AM) and evening (PM) peak periods when traffic was heaviest. Peak-hour condition (heaviest traffic flow) was determined and entered into Synchro. Counts were not conducted in Roosevelt for the morning and one

intersection (200 East) in the evening period. The 200 East intersection evening traffic was balanced first on US 40 for traffic entering from adjacent streets, and other movements were then adjusted based on similar movements at other intersections. The morning traffic condition along this section used a reverse percentage flow from the evening period along this corridor. To adjust for the difference in morning versus evening, an average percentage difference calculated from all intersections in Vernal was used.

B.2.2 Summary of Analysis

Table B.2-2, Table B.2-3, Table B.2-4, and Table B.2-5 below summarize the existing (2007) level of service and seconds of delay for each approach of each of the study intersections in Vernal and Roosevelt.

Table B.2-2. Delay and Level of Service at Intersections on US 40 in Vernal in 2007 during the AM Peak Period

	Seconds of Delay and LOS				
	US 40		Cross Street		Overall Intersection Delay and Corresponding LOS
Intersection	EB	WB	NB	SB	
100 South	19.3 sec B	18.5 sec B	56.5 sec E	24.3 sec C	27.2 sec C
500 West	5.2 sec A	2.6 sec A	26.7 sec C	30.3 sec C	7.6 sec A
100 West	1.1 sec A	1.5 sec A	34.9 sec C	34.7 sec C	3.6 sec A
Vernal – Route 191	3.5 sec A	5.4 sec A	24.1 sec C	27.1 sec C	10.2 sec B
500 East	2.7 sec A	3.0 sec A	33.1 sec C	33.5 sec C	8.0 sec A

Table B.2-3. Delay and Level of Service at Intersections on US 40 in Vernal in 2007 during the PM Peak Period

Intersection	Seconds of Delay and LOS				Overall Intersection Delay and Corresponding LOS
	US 40		Cross Street		
	EB	WB	NB	SB	
100 South	34.0 sec C	50.6 sec D	86.7 sec E	22.9 sec D	46.2 sec D
500 West	14.5 sec B	38.5 sec D	63.0 sec E	35.4 sec D	33.6 sec C
100 West	1.2 sec A	2.8 sec A	44.2 sec D	41.0 sec D	5.7 sec A
Vernal – Route 191	164.8 sec F	7.6 sec A	112.8 sec F	32.5 sec C	74.1 sec E
500 East	5.9 sec A	11.3 sec B	36.3 sec D	46.2 sec D	15.5 sec B

Table B.2-4. Delay and Level of Service at Intersections on US 40 in Roosevelt in 2007 during the AM Peak Period

Intersection	Seconds of Delay and LOS				Overall Intersection Delay and Corresponding LOS
	US 40		Cross Street		
	EB	WB	NB	SB	
State Street	1.9 sec A	0.4 sec A	29.5 sec C	29.6 sec C	4.2 sec A
Lagoon Street	7.8 sec A	7.7 sec A	17.1 sec B	13.3 sec B	13.1 sec B
200 East	26 sec C	21.1 sec C	8.7 sec A	15.8 sec B	17.4 sec B
North 600 East	2.2 sec A	2.9 sec A	26.9 sec C	26.9 sec C	6.3 sec A

Table B.2-5. Delay and Level of Service at Intersections on US 40 in Roosevelt in 2007 during the PM Peak Period

Intersection	Seconds of Delay and LOS				Overall Intersection Delay and Corresponding LOS
	US 40		Cross Street		
	EB	WB	NB	SB	
State Street	2.5 sec A	2.3 sec A	30.4 sec C	30.7 sec C	5.7 sec A
Lagoon Street	9.5 sec A	9.5 sec A	18.0 sec B	18.3 sec B	15.7 sec B
200 East	33.1 sec C	29.8 sec C	24.8 sec C	26.9 sec C	28.5 sec C
North 600 East	3.4 sec A	3.5 sec A	28.7 sec C	28.8 sec C	7.4 sec A

In summary, all intersections in Roosevelt are operating at LOS C or better. Some of the intersection approaches in Vernal operate at LOS E or LOS F during the PM peak period due to the higher traffic volumes.

B.3 Future Level of Service

B.3.1 Traffic Forecasting Methodology for the Level of Service Analysis

To forecast future levels of service along the US 40 highway segments, the team reviewed 20 years (1986–2005) of US 40 traffic count data. These data were used to develop annual forecasts for the 12 highway segments through 2035.

To forecast future levels of service for signalized intersections in Roosevelt and Vernal, the team reviewed data collected through other study efforts (such as the ongoing Vernal Bypass investigation by the Uintah Basin Transportation Special Services District) and collected new information at intersections with heavy turning volumes and at signalized intersections that had not previously been studied.

The forecasts for future traffic volumes used the trend that was set by the existing counts and established a forecast using regression-based analysis to find a fitted curve that best fit the established trend. Using the regression methodology, three forecast equations were reviewed, and the most applicable one was selected to develop a best representation of traffic volumes along the corridor (that is, an R^2 value closest to 1). This equation was used to create the long-range (30-year) forecast for the corridor. The forecast was populated on an annual basis for the 30-year period, and then an overall rate was established for each highway level of

service analysis segment. The actual equation that was used for development of the forecast is as follows:

Where X is years and Y is traffic count numbers,

- The equation for FORECAST is a+bx, where:

$$a = \bar{y} - b\bar{x}$$

and:

$$b = \frac{\sum (x - \bar{x})(y - \bar{y})}{\sum (x - \bar{x})^2}$$

and where x and y are the sample means AVERAGE(known_x's) and AVERAGE(known y's).

Intersection counts were factored up on an annual basis to represent years 2012, 2020, and 2035 for forecast intersection level of service calculations. Without having historical count data on intersecting roads, all intersection movements were factored using an equal percentage based on traffic growth rates for US 40.

In addition to total traffic, the forecasts considered the trend of vehicle type. This was important because truck traffic has grown from about 20% of the total volume to about 33% of the total volume on the east end of the corridor (near Vernal/Naples) over the last 20 years. Oil and gas providers, shippers, and lease permitting authorities expect this trend to continue (HDR 2007). Estimates for the year 2035 predict that 47% of the volume on the east end of the corridor will be trucks, with the percentage decreasing toward the west end of the corridor (Heber City).